

Name _____ Period _____

Lab Partners _____

Soil Lab: Drainage Rate and Pore Size

Introduction

Soils are composed of different physical combinations of mineral particles and organic matter in many different sizes. One of the most important physical properties of soil is known as soil texture. Soil texture, by definition, is the size of mineral particles in the soil. Mineral particle size is a major factor that influences both the amount of air in soil (**aeration**) and the capacity of soil to retain water (**water holding capacity**). The volume of air and water that soil can hold is known as the soil pore size or **porosity**. The larger the soil particles, the larger the soil pore size will be (see Figure 1). The reverse is also true—the smaller the soil particles size, the smaller the pore size (Figure 1).

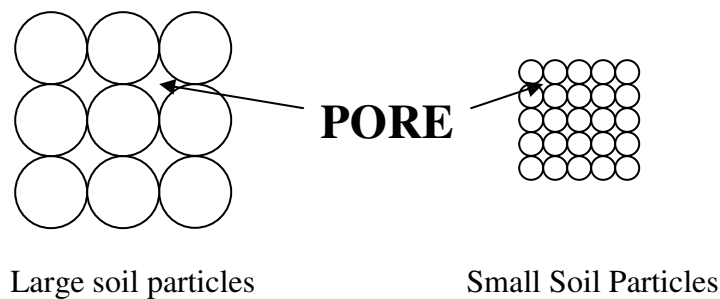


Figure 1. Pore size is directly proportional to particle size.

Water tends to drain more rapidly through larger soil pore size than small pores. As water runs through any type of soil, it pulls small amounts of air along with it. When water enters soil that has a small pore size, the air fills the pores or voids in the soil. As the small pore spaces are filled, the soil holds or retains a greater amount of water. This is why it is important to have a good mixture of different types of soil for plant growth. A combination of large and small pores provides both better aeration and water retention in soil.

Permeability is another key characteristic of soil. **Permeability** is the relative ease with which water and air can move through soil. Water flows through soils with high permeability very easily. Soils with low permeability allow much less water flow or drainage. Soils that have high permeability can be pictured as being loose and soils with low permeability can be thought of as being tight or compacted.

Compaction of soil also plays a major role in the amount of water that is drained through soil. **Compaction** occurs when pressure is applied to a soil surface. As soil becomes compacted, the pores in the soil become smaller. The number of large pores decreases, which, in turn, lowers the aeration level of soil. Compacted soil also leads to a decrease in permeability.

Permeability also decreases when soil becomes saturated with water. Saturation of soil and high levels of introduced water (rainfall for example) lead to runoff of water. Runoff is water that is not absorbed by the soil and flows to lower ground, eventually draining into streams, lakes, rivers, and other bodies of water. Excessive amounts of water runoff can cause severe flooding, which can lead to extensive property damage.

The composition and size of soil particles determine the type of soil. Soil type, in turn, determines the numbers and kinds of organisms that live in the soil. Thus, different kinds of plants and animals in an ecosystem are supported by different soil types. For example, desert plants survive best in fast-draining soil. Plants that require larger amounts of water survive best in soil that holds more water and drains more slowly.

Quick Review

Define the following words:

- Aeration-
- Water holding capacity-
- Porosity-
- Permeability-
- Compaction-

Day 1 Data

Table 1: Dry Soil Drainage

Soil	Time of Drainage (s)
Tube 1 Loose Soil	
Tube 2 Packed Soil	

Table 2: Wet Soil Drainage

Soil	Time of Drainage (s)
Tube 1 Loose Soil	
Tube 2 Packed Soil	

Day 1 Analysis

1. Which drained faster, the dry loose soil or the dry packed soil?
2. Which drained faster, the wet loose soil or the wet packed soil?
3. Which drained faster, wet or dry soil?
4. Therefore, during a rainstorm, which of the following types of soil would drain the fastest and which would drain the slowest? (write the letter on the appropriate blank)
 - A. Loose soil at the beginning of the storm
 - B. Packed soil at the beginning of the storm
 - C. Loose soil at the end of the storm
 - D. Packed soil at the end of the storm

Fastest _____ Slowest _____

Day 2 Data

Table 3: Permeability and Porosity

	A	B	C	D	E
Soil Type	Initial Time (s)	Amount of Water Remaining in Graduated Cylinder (mL)	Pore Space Volume (mL) (100mL – Column B)	Water Drained From Tube (mL)	Water Retained (mL) (C – D)
Sand					
Coarse Gravel					

Day 2 Analysis

5-8. Put an X in the appropriate column for each question.

Use your data in Table 3 to help you.

	Sand	Gravel
5. Bigger Particles		
6. Bigger Pore Size (larger spaces between particles) Hint: See Column C		
7. Better Water Holding Capacity (retained more water) Hint: See Column E		
8. Better Permeability (water moved faster through it) Hint: See Column A		

Conclusions

Use the introduction, “quick review” vocabulary, your data, and your analysis to circle the correct answers in parentheses.

9. As soil becomes more **compacted**, **permeability** (increases, decreases).

Hint: Review the definition of permeability and look at your data in Tables 1 and 2.

10. As soil becomes more **saturated** with water, **permeability** (increases, decreases).

Hint: Review the definition of permeability and look at your data in Tables 1 and 2.

11. Soils with bigger particles have (bigger, smaller) **pore sizes** than soils with smaller particles.

Hint: Look at the trends in your chart for #5-8.

12. Soils with bigger particles have (better, worse) **water holding capacities** than soils with smaller particles.

Hint: Look at the trends in your chart for #5-8.

13. Soils with bigger particles have (better, worse) **permeability** than soils with smaller particles.

Hint: Look at the trends in your chart for #5-8.

Soil Lab Procedures: Drainage Rate and Pore Size

Activity One: Drainage Rate of Dry Soil

1. Obtain 2 clear tubes with open ends.
2. Rubber-band 2 pieces of cheesecloth to one end of each tube.
3. Place each tube upright, with cheesecloth end down, in a plastic cup.
4. Place 40 mL of loosely packed soil in tube #1 (Note: it has already been measured).
5. Place 40 mL of soil in tube #2. (Note: it has already been measured). Tightly pack the soil down, using a wooden dowel.
6. Hold tube #1 above the plastic cup and pour 20mL of water into the tube. Use a stopwatch or a watch with a second hand to time the drainage of the water. Start timing as soon as all of the water has been poured into the tube.
7. Stop timing when the water stops dripping from the bottom of tube #1. Record time under “Time of Drainage” for “Loose Soil” in Data Table 1.
8. Repeat Steps 6 and 7 for tube #2. Record the time for drainage of the water in tube #2 in seconds under “Time of Drainage” for “Packed Soil” in Data Table 1.
9. Pour the water from each cup into the appropriate bucket. Save the tubes with the soil and the cups for Activity 2.

Activity Two: Drainage Rate of Wet Soil

10. Place each of the tubes with the wet soil in the cups once again.
11. Hold tube #1 above the cup and once again fill the tube with 20 mL of water. Start timing as soon as all of the water has been poured into the tube.
12. Stop timing when the water stops dripping from the tube. Record drainage time for the first tube in seconds under “Time of Drainage” for “Loose Soil” in Data Table 2.
13. Repeat steps 11 and 12 for tube #2. Record the time for the second tube under “Time of Drainage” for “Packed Soil” in Data Table 2.
14. Dispose of the soil and cheesecloth in the garbage can and clean the tubes using the appropriate buckets.

Activity Three: Permeability and Porosity of Varied Soil Types

15. Obtain a tube with one end closed.
16. Pour in the 100 mL of sand (Note: it has already been measured).
17. Measure 100.0 mL of water into a graduated cylinder. This will be the initial amount of water.
18. Start a timer and slowly pour water from the graduated cylinder into the tube until ALL of the sand is saturated. Record the amount of time it takes the water to saturate ALL of the sand (from bottom to top!) in Data Table 3 under "Initial Time."

NOTE:

- DO NOT POUR ALL OF THE WATER INTO THE SAND!
 - THERE SHOULD **NOT** BE A LAYER OF WATER ON TOP OF THE SAND
 - LET THE WATER SOAK IN BEFORE YOU ADD MORE
19. Set the graduated cylinder containing the remaining water aside for now.
 20. Record the "Amount of Water Remaining in the Graduated Cylinder" in Data Table 3.
 21. Subtract the amount of water remaining in the graduated cylinder from the initial volume of water, 100 mL. This will give the volume of the pore spaces in the sand. Record this value in Data Table 3 as "Pore Space Volume."
 - $100 \text{ mL} - (\text{Column B})$
 22. Pinch the tube and pour the water retained in the sand from the tube into the smaller (50mL) graduated cylinder. Be sure not to pour any of the sand into the graduated cylinder. Record this amount of water as "Water Drained from Tube" in Data Table 3.
 23. Subtract the "Water Drained from Tube" from the "Pore Space Volume" of the sand. This value will be the volume of water retained. Record this value in Data Table 3 as "Water Retained."
 - $\text{Column C} - \text{Column D}$
 24. Dispose of the sand sample in the appropriate bucket and repeat steps 15-23 for the coarse gravel sample.
 25. Rinse, clean, and dry all of your cups and tubes and return them to your bin.